

Coordination of Heterogeneous Robot Swarms for Planetary Logistics Operations, Phase I

Completed Technology Project (2018 - 2019)



Project Introduction

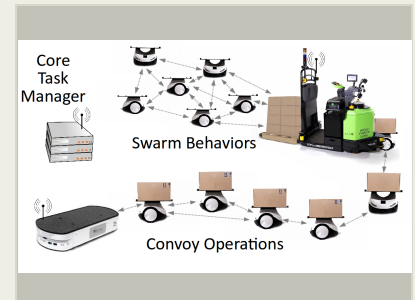
Swarm robotics is one of the key enabling technologies for significantly extending mankind's reach beyond the Earth's surface. However, when bringing theory to practice, challenging problems related to the coordination and control of these swarms quickly arise. Vecna Robotics proposes a collaboration with MIT to extend existing autonomy behaviors and test platforms to address a class of planetary robotic operations involving heterogeneous teams of robots working together to accomplish a joint mission, with examples such as sample collection and mining. In these example applications, robots must perform coordinated task planning, operation, and execution while observing mission constraints that arise due to the asymmetric capabilities of the robot platforms. At pick-up and drop-off locations, there may be significant density of robots, requiring fast, real-time, coordinated motion planning to avoid collisions and achieve the desired behavior. To perform certain tasks, swarms of robots must localize relative to one-another to, for example, hold a formation while transiting from one task area to another.

The Vecna-MIT team will address these challenges by developing a system that both has high requirements for autonomy and can handle heterogeneous robot teaming. There are three key areas of work to achieve the goal: 1) develop functionality that can accept high-level goals and recruit agents to meet the goals, 2) implement a set of local platform autonomy behaviors that enable swarm-like functionality, and 3) implement a task-arbitration system that can switch between "swarm" behavior and more traditional autonomy. The proposing team will leverage their unique capabilities to provide limited testing of the swarm behaviors on existing test beds as part of the Phase I. The results of this work can contribute not only to NASA's objectives but also in the defense, disaster-recovery, and commercial sectors as well.

Anticipated Benefits

This work supports NASA's objective to send swarms of vehicles to polar regions on Mars to search for frozen water sources or asteroids to mine precious metals. The solution can also serve as a base for other swarm applications, such as spacecraft. One application could be to swarms of drone-analogs that NASA is working on: Extreme Access Flyers, which could explore more distant locations on Mars, the moon, or asteroids.

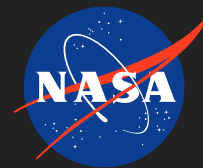
The logistics industry is prime to benefit from swarm robotics applications. One application is to have "carrier" robots that interface with a central, more sophisticated retrieval robot to move boxes within a large package handling facility. Swarm behaviors can be used to coordinate complex motion around fixed automation equipment such as robotic picking arms. Autonomous swarm technology can also benefit defense and disaster recovery applications, both challenging environments for humans.



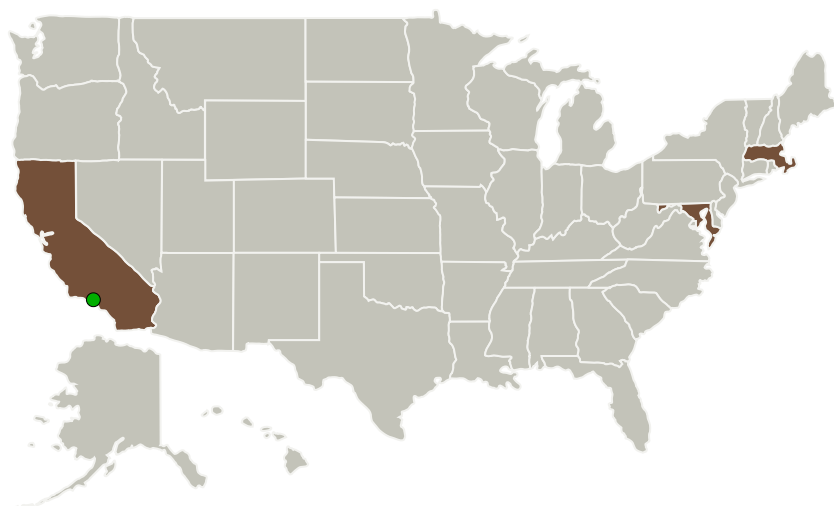
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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Vecna Technologies, Inc.	Lead Organization	Industry Women-Owned Small Business (WOSB)	Greenbelt, Maryland
 Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California
Massachusetts Institute of Technology(MIT)	Supporting Organization	Academia	Cambridge, Massachusetts

Primary U.S. Work Locations	
California	Maryland
Massachusetts	

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Vecna Technologies, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

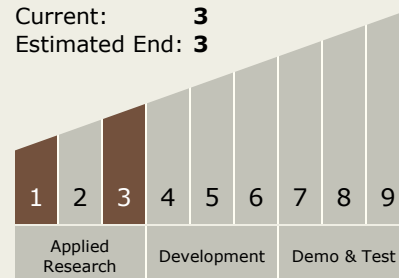
Carlos Torrez

Principal Investigator:

Zachary Dydek

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**




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Project Transitions

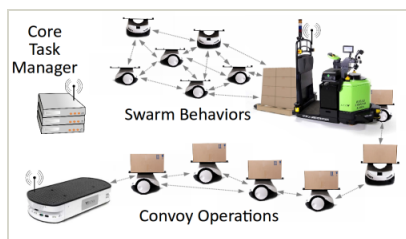
 **July 2018:** Project Start

 **August 2019:** Closed out

Closeout Documentation:

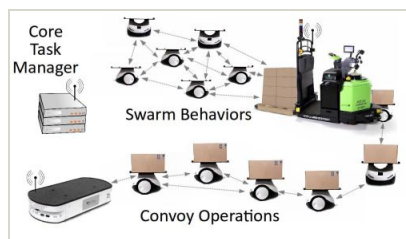
- Final Summary Chart(<https://techport.nasa.gov/file/141319>)

Images



Briefing Chart Image

Coordination of Heterogeneous Robot Swarms for Planetary Logistics Operations, Phase I
(<https://techport.nasa.gov/image/131469>)



Final Summary Chart Image

Coordination of Heterogeneous Robot Swarms for Planetary Logistics Operations, Phase I
(<https://techport.nasa.gov/image/127235>)



Final Summary Chart Image

Coordination of Heterogeneous Robot Swarms for Planetary Logistics Operations, Phase I
(<https://techport.nasa.gov/image/125848>)

Technology Areas

Primary:

- TX04 Robotic Systems
 - └ TX04.4 Human-Robot Interaction
 - └ TX04.4.2 Distributed Collaboration and Coordination

Target Destinations

Earth, The Moon, Mars